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Recommended Citation

Akkaladevi, Somasheker and Luo, Xin, "Bottlenecks in the Process of Improving ICT Infrastructure in Developing Countries: A Chinese Perspective" (2008). *AMCIS 2008 Proceedings*. 398.
<http://aisel.aisnet.org/amcis2008/398>

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Bottlenecks in the Process of Improving ICT Infrastructure in Developing Countries: A Chinese Perspective

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ABSTRACT

We live in the era of information technology. The development of Information and Communication Technologies (ICTs) is vital to the survival of any economy. ICT involves innovations in microelectronics, computing (hardware and software), telecommunications, semiconductors, and fiber optics, etc. Technological innovations, such as the wide diffusion of mobile phones and wireless Internet, play a paramount role in building ICT levels globally. With an emphasis on the Chinese economy, this paper discusses the issues and challenges involved in ICT investments and further explore factors that influence ICT policy formulation and how these factors impact on the implementation. Future infrastructure expenditure needs and financing options and the practical framework needed to develop the strategies to build ICT infrastructure are also presented.

KEYWORDS

E-Commerce, China, GDP, Information and Communication Technologies (ICT), Infrastructure, Information Technology.

INTRODUCTION OF ICT

ICTs are tools which are used for exchanging information and handling information effectively. They include the “old” ICTs of radio, television and telephone, and the “new” ICTs of computers, satellite and wireless technology and the Internet. These different tools are now able to be synchronized and combined to form our networked world – a massive infrastructure of intra and interconnected telephone services, standardized computing hardware, the Internet, radio and television.

It is widely acknowledged that telecommunication is a basic yet desirable infrastructure necessary for economic and social development of a country. This fact is even becoming more prevalent than ever as information-related economic activities are growing at a rapid pace, as ICT may be described as the support to the central nervous system of complex societies, which transmits and processes information and commands among the various parts of such societies.

The phenomenal evolution of the information society mirrors the dramatic changes in business activities. In a larger social context, the rapid advancement of IT is drastically restructuring the information society which carries high hopes of global users towards wealthier life, greater social interactions, increased knowledge and more productive livelihoods. Evolution of the information society entails dramatic changes in production and business activities, as well as in a larger social context. The transformation of information society can only be understood if we view it in broader context where bits, networks and knowledge have a social meaning. To understand the results of technological change we have to study the social dimension of information society. Rapid development of information technology is drastically altering the structure of work and employment, and producing new occupations and jobs. More and more people are being drawn into the information society as learners, workers and consumers. People all over the world have high hopes that new technologies will lead to wealthier life, greater social freedom, increased knowledge and more productive livelihoods [17].

As such, it is predictable that our succeeding generations will encounter the challenge of adjusting to a new social environment, where information and scientific knowledge will replace matter and energy as pivotal factors and will define both society's strategic potential and prospects for its development [18].

Bolstering and enabling interactive communication unhindered by distance, volume, medium, or time, ICT infrastructure offers economies of scale that stimulate network building and consequent spillover benefits. Moreover, ICTs promote greater inclusion of individuals within networks and, even more importantly increase the diversity of participants by overcoming the barriers of physical distance and social standing. The immediacy and reach of ICTs also promote faster, more efficient, and ultimately better decision making across all fields of endeavor [17].

ICT ROLE IN CHINESE ECONOMY: A Socialtechnological Transformation

Internet plays a fundamental function in the role of implementing and leveraging ICTs. The ever-increasing development of Internet in a nation or a region has become a matter of concern for governments and societies. For the last decade, Internet in China has experienced rapid development.

The Internet has a profound impact on the phenomenal economic advancement of China. To some extent, the Internet has completely changed the traditional way of doing business (i.e.: e-commerce) which was deeply rooted in Chinese Confucian philosophy, and also changed the way people relate to each other in society (i.e.: email, instant messaging). Recognizing the Internet's potential influence, Chinese government has embraced and been involved in the further development of the Internet. Considered as a collectivism country where people tend to cohesively integrated into groups, China is undergoing significant yet gradual transformation towards social networking which is based on "*guan xi*" (interpersonal connections or networking). With the use of Internet, much of that is reduced since purchaser, for instance, can find a supplier and the business can thereby be done directly.

Embarking as one of the fastest-growing emerging economies, China is making waves around the world due to its impressive 9% annual economic growth rate. Its contribution to global GDP growth since 2000 has been almost twice as large as that of the next three biggest emerging economies (India, Brazil and Russia) combined.

Driven by the strong demand of Chinese customers, the competition in China's telecommunication market is becoming more severe. Almost all major vendors around the world have set up sales teams, localization development teams, and technical support teams, etc in China. Over time, more and more companies feel that they must have a core-technology R&D lab in China in order to succeed in this challenging market and grab a share of opportunities in this growing country. ICTs are therefore playing a vital role in today's Chinese market. In just a few years, China has become the country in the world offering the most attractive market perspectives for most ICT products and services, thus making ICT a key focus for cooperation between the European Union and China.

Hardware, Software and system integration

There are about 10,000 software companies in China, 3000 of which are exclusively engaged in software development [16]. Over 100 of these companies are wholly foreign owned and joint ventures. China's IT sector is prepared for the opening of the market, as most enterprises were established under the market-oriented economic system.

On the manufacturing side, quite a number of enterprises have been restructured into conglomerates, and have established national distribution networks and even begun supplying overseas markets. For example, the Chinese telecommunications company Zhongxing sells their telecom network solution products to nearby countries such as Pakistan, Laos and Burma [8]. Additionally, China's computer market has grown rapidly in recent years. The ongoing transition to digitization in domestic telecommunications and in the financial sector in addition to the enormous demand for IT applications for the home has greatly promoted growth in hardware sales. In general, hardware constitutes the largest share of China's IT market, although demand for software and information services is growing tremendously.

Internet

The existing public network already covers most of the major cities in China and the Internet is becoming an inseparable part of daily life in China. Internet Service Providers (ISP) and Internet Content Providers (ICP) are looking forward for foreign investment (which is currently not permitted) in their sectors, as domestic investors do not yet have a very sophisticated understanding of the investment opportunities in Internet companies.

HISTORY OF ICT GROWTH IN CHINESE MARKETS

The ICT industry in China has developed rapidly over the past decade and now plays an important role in the country's economic development. The telecommunications sector has averaged an annual growth of 44 percent in domestic sales over the last five years [1]. And China is currently drafting the telecommunication management rules and regulations, telecommunication laws, business management regulations on foreign investment in telecommunication services. The government is also drafting the 10th Five-Year Plan and the 2015 Long-Term Development Plan for key industry sectors, the stated aim of which is to establish a fair, transparent and effective market competition mechanism [1].

With the constant advance in IT, infrastructure also needs to improve to meet the growing demand for Internet access. Today, growth in e-commerce, e-government, and distance learning is barely able to keep up with demand for those services. The

increasing number of ways the Internet is being used requires new, reliable infrastructure. Accordingly, China has greatly increased its investment in Internet infrastructure and laid a solid foundation to allow the Internet-based market to expand. For example, from 1992 to 2002, the capacity of the long-distance telephone exchange increased from 521,885 to 7,730,133 circuits, and long-distance optical cable lines increased from 14,388 km to 487,684 km. Bandwidth for international connections increased from 25 megahertz (MHz) in 1997 to 53,941 MHz by June of 2004 [9].

Raising the proportion of users with broadband access is an important goal for the telecommunications sector. Regarding the backbone network, Internet protocol synchronous digital hierarchy (IP SDH) is increasingly gaining acceptance, and dense wavelength division multiplexing (known in China as “IP DWDM optical”) technology is also gaining popularity and is used in some networks. The Internet backbone network has now reached all provincial capitals, and the bandwidth among the key Internet nodes is generally above 155 MHz, and as high as 622 MHz or even 40 GHz on some key routes [9].

BENEFITS FROM ICT IMPLEMENTATION IN CHINA

ICT infrastructure is useful for dissemination of scientific results world-wide through scientific knowledge sharing and exchanging. ICT also allows setting up of Virtual Labs for communications and remote instrument control. Furthermore, ICTs can be used for the reorganization of internal administration and alternative provision of services, thus cutting administration costs. ICT applications support development programs in many urban and rural areas. Databases, drawing facilities, simulation and modeling tools are integral supports for making decisions in planning, management, and development. In the transport sector, advanced telematics can improve road safety, maximize road-transport efficiency, and can also be used for solving the environmental problems such as congestion, pollution, and resource consumption [4].

In the year 2006 Chinese Ministry of Education estimated that 300 digital opportunity centers would be needed to set up in 168 rural areas across nation-wide which involves in various activities to help the ICT infrastructure facilities [3]. The Ministry hopes to use community as the subject where related hardware and software information and network infrastructure are established so that residents in the community may start to learn e-education step by step and at the end, the nation's quality of education in IT may be enhanced. By establishing rural information centers, ICTs can create employment opportunities in rural areas by engaging telecenter managers, subject matter specialists, information managers, translators and information technology technicians. Such centers help bridge the gap between urban and rural communities and reduce the rural-urban migration problem. These centers can also provide training to those who may become small-scale entrepreneurs.

With the advent of new ICTs, China's rural communities can thereby acquire the ability to improvise their living conditions and become motivated through training and dialogue with others to a level where they can make decisions for their own development.

The rapid development of China's ICT industry provides many opportunities for supply and cooperation [4]. The key areas include: Linux, Inlaid software, E-commerce, Telecommunications network management software, Supply chain management (SCM), Enterprise resource planning (ERP), Customer relationship management (CRM), and the Internet.

The improvement in ICT infrastructure in China paves the way for opportunities in the following areas:

- E-commerce – Credit assessment, e-commerce between businesses (B2B) solutions to realize payment online and ensure credit security. There are also opportunities in the provision of management software, including innovative solutions for planning, scheduling and forecasting, distributing, transporting, and warehousing. There will be competitive advantages in payment systems for financial settlement, Encryption and security, Internet tools, Internet applications, Management suites, Bandwidth solutions software and systems, Value-added services (call centers and consultancy).
- Hardware – A range of network connection products, network access cards, servers, routers, innovative components, digital audio-visual frequency systems and professional TV broadcasting station filming, recording and editing equipment.
- Telecommunications products – Data network connection technology, Interconnection billing systems, users access products, telecommunications power supply systems, HF and VHF communication products, consultancy and training to improve network efficiency.

The increasing development of Chinese ICT infrastructure can also provide opportunities in Industry application system and software's, taxi dispatching systems, special purpose SCADA systems, i.e. water survey, geo-mapping, gas supply pipe-line monitoring, distance education, and total system solutions for the security of banks and other important facilities.

THE CHALLENGES

The fast development of Internet services has accelerated online trading in the eastern and southern regions of China. There are approximately 670 business-to-business (B2B) websites in China. Beijing, Shanghai and Guangzhou are stand-out centers of e-commerce, with the fastest expansion of Internet services and e-commerce in the country [15].

Although Internet and e-commerce are developing rapidly in China, there are still many issues for new market entrants to be aware of, such as low level of information knowledge among enterprises, lack of security for online business transactions, and infrastructure for online payment needs to be improved. To overcome these challenges, the Chinese government constantly studies and puts efforts to improve the environment for e-commerce [5].

Over the last 12 years, the telecommunication/ICT sector has undergone a variety of major changes. Estimates for 113 countries over a 20-year period show a positive link between telecommunications infrastructure and income, as well as between telecommunications infrastructure and gross domestic product (GDP) [11]. The estimates suggest that a 1 percent increase in the telecommunications penetration rate might be expected to lead to a 0.03 percent increase in GDP. With high growth in the mobile sector, mobile penetration rates stood at more than 40 percent at the end of 2006. International Telecommunication Union (ITU) data suggest that the number of mobile cellular subscribers surpassed the 3 billion mark in August 2007 [12].

Asian governments constantly review each other's strategies on advanced technology infrastructures and deregulation, leading to the quick diffusion of similar Internet development practices in the leading Internet economies of Hong Kong, China; Singapore; the Republic of Korea; and Taiwan. Some of the top Internet service providers and suppliers in Asia and the Pacific are tapping into new service development opportunities in non-traditional markets, such as China and India [7].

Japan's NTT DoCoMo, one of the earliest mobile Internet service providers, has a new research and development (R&D) operation in Beijing reportedly developing fourth-generation (4G) technology that is 10 times faster than any network operating today. Cisco Systems has also planned opening an Asian R&D centre in Shanghai, China, to supplement work done at its largest regional centre, in India [7]. Both companies aim to benefit from China's lower development costs and to demonstrate long-term commitment to one of the world's largest future Internet markets [13].

The Asian and Pacific region continues to witness robust growth in investment in basic ICT infrastructure, particularly in China which has maintained consistently high ICT and economic growth after adopting entrepreneurial and free market principles in the 1980s [16]. It has the region's largest network and one of the world's largest markets for ICT equipment and services. Many major cities are reaching telecommunications saturation but penetration in the rest of the country is still low compared with developed countries, particularly in rural areas.

India is still in the earliest stages of Internet development compared with some other countries of the Asian and Pacific region. Despite significant progress in Internet and software development, India's lack of Internet infrastructure, outdated and costly service regulation in some key areas, and the slow pace with which it implements development plans, puts its Internet status behind a more aggressive China [7]. Moreover, it suffers from an extreme divergence between the small percentage of its people who are spearheading the expansion of the Internet economy with world-class capabilities, and a large percentage of the population living in some of the region's most dire conditions of poverty who will not have access for years.

Developing a strong Internet environment is a common goal for Asian and Pacific governments, but the quality of government support varies greatly when it comes to implementing e-business and wider e-societal initiatives and fostering the necessary telecommunications infrastructure. Countries and areas such as Hong Kong, China, the Republic of Korea, Singapore and Australia are shaping technical, legal, economic and social environments to promote Internet use, but many other countries are lagging behind. In order to create an environment that promotes wider use of the Internet and an all-inclusive information society, we need to overcome the following challenges [7]:

- Making the Internet available to everyone. Improving the local infrastructure and reducing access costs enable large parts of the local population to go online. Creating an enabling environment that encourages needed investment and public-private partnerships to expand the much-needed rural infrastructure is another important challenge [5].
- Developing legal and security frameworks for online activities. For example Australia, the Republic of Korea and Singapore have taken the lead in developing comprehensive e-legislation that covers digital signatures, encryption, public key infrastructure, protection of intellectual property and online taxation [5].

The availability and quality of basic ICT-related infrastructure are very important for determining the location of globalised services activities and, therefore, the possibility for Chinese based activities to be part of the global supply of services. The Chinese ICT sector has grown rapidly. The domestic ICT market was valued at \$156 billion in 2004 [6]. According to the

Organization for Economic Co-operation and Development (OECD), China led the world with \$180 billion of ICT exports in 2004, surpassing the United States [10]. At the same time, Although China is a leading exporter of semiconductors; it still needs to import chips to meet local needs. China still needs to commercialize the third-generation (3G) mobile technology in the mainland. Although Lenovo, China's leading personal computer (PC) firm is the third largest in the world, there are only an estimated 65 million computers in a country with a population of over 1 billion people [10].

The PC industry has followed the pattern of other technology markets in China. A major challenge for China's computer industry will be to expand beyond production of PCs for the domestic market and low-value peripherals and components for the global market. Given the country's strong technical skills and ability to attract foreign investment and technology, it has a reasonable chance of meeting this challenge.

Software is a key pillar of China's IT industry. Both the central and the local governments (such as Beijing and Shanghai) are promoting the industry by facilitating funding for software startups and incubators. For example, Chinese software companies do not have to pay taxes during their first two years of operation and receive a 50 percent tax break in the third and fourth years. The industry also benefits from simplified administrative procedures and relatively fast approval of foreign investment. In addition, preferential treatment is given to research facilities that successfully commercialize their research, and local governments have provided financial support for the construction of software parks.

The Chinese software-outsourcing industry is highly fragmented and lacks large players dedicated to outsourcing. Expanding Internet access, as well as escalating network and computer security attacks, are driving demand for information and network security services in China.

The demand from China's large domestic market and foreign export markets offers huge opportunities for its ICT industry. Innovation and R&D capacities are critical for the industry to attract investment, maintain high growth, and become globally competitive. China must address the barriers to more effective innovation by introducing regulatory and policy reforms, encouraging collaboration, and increasing government support. Table 1 shows the different countries patents activity in different Research and development areas received by Patent Cooperation Treaty (PCT) organization [20].

	2002	2003	2004	2005	2006	Annual growth (%)
Total	110,392	115,199	122,624	136,500	145,300	6.4
U.S.A.	41,296	41,028	43,350	46,697	49,555	6.1
Japan	14,063	17,414	20,263	24,841	26,906	8.3
Germany	14,326	14,662	15,218	16,000	16,929	5.8
Korea, Rep. of	2,520	2,949	3,558	4,688	5,935	26.6
France	5,089	5,171	5,185	5,741	5,902	2.8
U.K.	5,376	5,206	5,026	5,085	5,045	-0.8
Netherlands	3,977	4,479	4,285	4,516	4,393	-2.7
China	1,018	1,295	1,706	2,493	3,910	56.8
Switzerland	2,755	2,861	2,899	3,277	3,403	3.8
Sweden	2,990	2,612	2,850	2,873	3,123	8.7
Italy	1,982	2,163	2,189	2,345	2,723	16.1

Table 1. International Patent Applications by Country of Origin

Economy-wide framework conditions are important factors in firms' decisions about where to locate their service activities. These include the cost and ease of setting up a business, and the procedures for enforcing contracts. Table 2 shows the average cost, procedures and time needed in various countries regarding the business setups [19].

	Cost of business start-up procedures (% of GNI per capita)	Procedures to enforce a contract (number)	Start-up procedures to register a business (number)	Time required to enforce a contract (days)
Brazil	11.7	25	17	566
Russia	6.7	29	9	330
India	49.5	40	11	425
China	15.8	25	13	241
South Africa	9.4	26	9	277
Philippines	19.4	25	11	380
Sri Lanka	10.7	17	8	440
Poland	20.6	41	10	1000
Czech Republic	10.8	22	10	300
Hungary	22.9	21	6	365
France	1.1	21	7	75
Germany	5.8	26	9	184
Japan	10.6	16	11	60
United Kingdom	0.9	14	6	288
United States	0.5	17	5	250

Table 2. International Patent Applications by Country of Origin

ICT applications make the flow of information more efficient and systematic, supporting the development of an information society. Currently, however, China's 111 million Internet users account for less than 9 percent of its population. Several obstacles impede the spread of Internet use and other information and communication technology (ICT) applications. First, many municipalities and local governments are unable to provide the public with affordable, convenient information access points. Second, significant ICT demand remains latent due to low awareness levels and usage rates. Third, domestic ICT providers are unwilling to cater to users given the seemingly modest demand. Until demand and supply are synchronized, ICT growth will remain slow.

Understanding how ICTs can service specific development goals requires both knowledge of appropriate technologies and a grounded appreciation of how these technologies can be deployed to address concrete problems. Figure 1, shows development of China's national ICT policies progression in the years 2000 and 2005 [19].

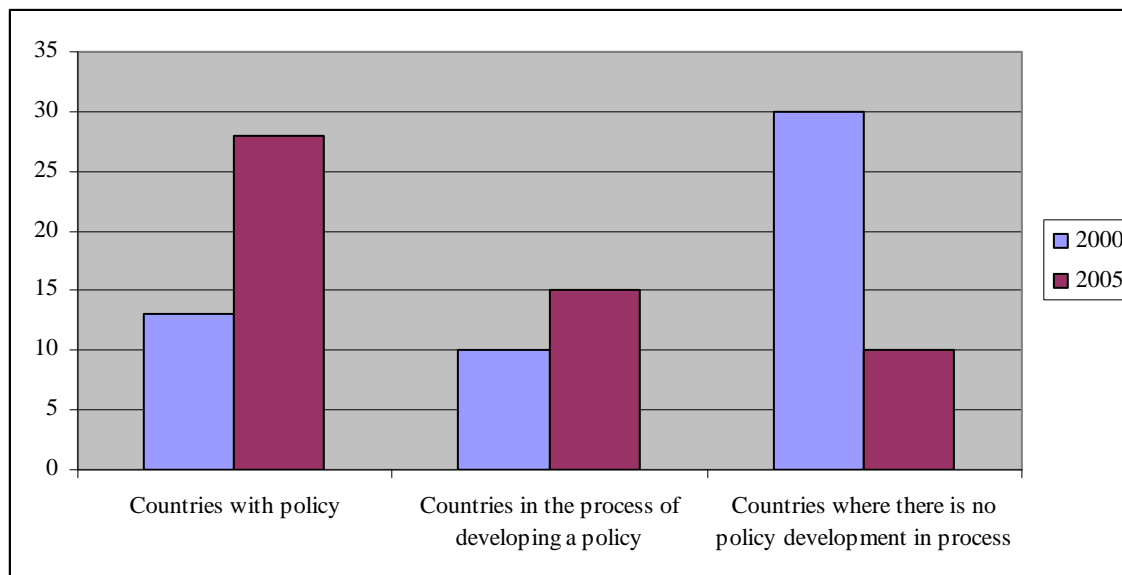


Figure 1. Development of National ICT Policy

DEVELOPING STRATEGIES TO IMPROVE ICT: A PRACTICAL FRAMEWORK & RECOMMENDATION

This section gives a practical framework for developing ICT infrastructure in government, and private organizations perspective. As developing countries such as China join the global information infrastructure, they will need to establish effective ways to maximize the benefits and control the risks of ICTs. This means coordinated action, encompassing the technologies and services, as well as many aspects of the institutional environment. Strategies are needed to establish the necessary Software and Technology, engineering knowledge, and management techniques and to build the social and economic institutions needed to reap the potential social and economic benefit of ICTs [2].

Business-to-consumer (B2C) opportunities are growing particularly rapidly in Asia. In China, for example, the most popular web site now has 1.3 million registered users and 220 million page views per month. This puts it broadly on par with Yahoo in the United States. Another Chinese site, organizing on-line auctions, has hosted over 153,000 auctions to date, with a gross value of over \$12m.

Business-to-business (B2B) start-ups are also becoming evident in some countries. Opportunities in this area include software authoring, back-office work for banks and insurance companies, publishing, medical transcription, data processing, creation of web pages, creation of databases and digitizing of engineering drawings and maps. The Indian software industry is one important example; it has grown at an annual rate of 56 percent over the last five years, contributing to 10 percent of the growth in India's GDP, and currently generating revenues of nearly \$4 billion per year. 500,000 people are now employed in the industry, 27 percent of which are women; this proportion has been increasing in recent years [14].

The role of the government

Government can play a significant role in stimulating ICT demand and supply. The government role in any country is crucial for the development of its economy. The Chinese government is probably the country's largest investor in ICT and can lead the adoption and use of ICT applications in several ways. One is for the government to become more capable with information technology (IT) and e-enabled. Government involvement is needed not only to provide budget but also to be the active user of ICT. The government can have a tremendous impact on the ICT sector as a user, purchaser, and provider of ICT services. E-government initiatives make public administration more efficient and transparent. It can also provide citizens with direct access to public services, improving interactions between officials and citizens. Key decision-makers and stakeholders need to make informed decisions about which technologies are most appropriate for their contexts and needs. Government needs to monitor and obtain additional funding in areas where private sector has little incentive to invest. The private sector, which has the greatest capacity to invest and innovate, provided an enabling environment in place. The private sector can be the critical motor for ICT development and key to its sustainable growth and outreach. Government budgets

with private enterprise investments are good partnerships for development. Government should propose activities to improve the role of ICT such as

- Stimulate people to develop, use and propagate content on the Internet that is relevant to them, addresses local issues, and reflect the cultural diversity and social values.
- Educate the public on the benefits of ICT and the way that business is being increasingly conducted in the new global economy.
- Establish working groups focused on ICT development, e.g. legal, regulatory, technical, social, cultural, education, economics, trade, and finance.
- Be the focal point to address emerging issues or trends that relate to ICTs, e.g. cross-border taxation within the context of global e-commerce.
- Monitor the development, implementation, and evaluation of standards, policies and regulations related to ICT, incorporating stakeholder benefits.
- Constantly monitor the proposed investments in ICT.

ICT access can be increased by maximizing Infrastructural Interdependencies. ICT infrastructure can be developed alongside other infrastructures to achieve national socio-economic development objectives. Different types of infrastructures are often interlinked and interdependent.

Improving on the governance policy

The best strategy to improve ICT is to focus on the policies we develop, for example we need to consider situations such as:

- High taxation which leads to ICT infrastructure inaccessibility.
- Labor market may become inefficient due to lack of proper ICT knowledge.
- Due to uninformed decisions there might be inadequate services in ICT infrastructure.
- ICT can also be improved by focusing on the accessibility of digital networks in the country, which presently is not up to the mark.
- New Internet based economy can be explored to a great extent through ICT infrastructure.
- Training opportunities can also be increased by using the technology.

Workshops and training with key gatekeepers and stakeholders need to be conducted because they can play a vital role in raising awareness about the potential for ICT development. Additionally, national summits, which can help nurture the formulation of national strategies and partnerships that encourage private sector participation, are also needed to engage a broad range of national stakeholders, including the state, private sector, academia and civil society. We believe that it is necessary to combine new technologies with the old ones. As such, the Internet can be combined with “old” technologies including community radio to more effectively overcome barriers of physical access, affordability, illiteracy. For example, in many developing areas, “wired” community radio stations operate as local broadcasting centers for Internet content, which they download and rebroadcast to thousands of illiterate listeners [19].

For the development of ICT, we believe China needs to have domestic and foreign enterprises that serve as the backbone of technology development and that are likely to invest in the development and commercialization of new technologies; Research institutes that serve as engines for innovation; Government agencies that can provide strategic direction and create an environment that fosters innovation, including funding and other support measures. In particular, China has a huge pool of talented young researchers in higher education institutes and lots of advanced technologies have thus been developed in China. Big companies need to invest more and more in R&D development collaborating jointly with various universities.

Investment in the development of network infrastructure capacity to take advantage of newer, cost-effective telecommunications and computer technologies is also necessary. develop Strategies need to be developed to foster the deployment of secure, cost-effective and sustainable Internet, protocol-based infrastructure, and value-added services in China as well as least developed countries worldwide.

CONCLUSION

ICT infrastructure can be useful for the development of any economy. Developing economies such as China must pursue an effective role in the formulation of national policies and strategies to further promote ICT in order to obtain benefits in terms of economic growth and development. The emergence of ICTs effects the business environment at national, regional and global levels, and generates major opportunities, new challenges for market growth and development of jobs, industries and services. Smooth integration of Chinese economy into an increasingly global knowledge and innovation system is needed. If managed properly, this integration can give the possibilities for development of China's capabilities in science, technology and it will be beneficial not only to China but also to the world at large. In this paper, based on the past, present, and future Chinese ICT artifacts, we discussed the issues and challenges involved in ICT investments, factors that influence ICT policy formulation, and finally we provided a practical framework needed to develop the strategies to build ICT infrastructure in perspective to developing countries.

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